Excitons in Electrostatic Lattices

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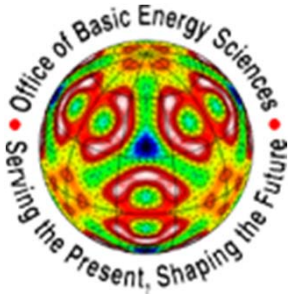
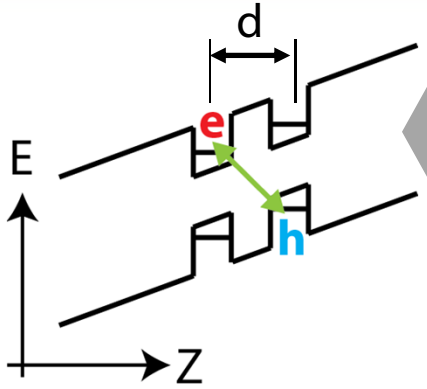
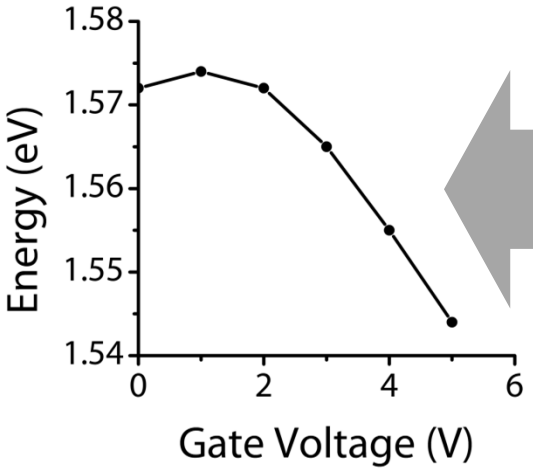
APS March Meeting 2011



Indirect Excitons



Bound pair of an electron and a hole confined to separate quantum wells



Indirect Exciton Energy is controlled by applied voltage:

$$\delta E = edF_z$$

More about indirect excitons:

Excitons in moving lattices

J. Leonard, 10:24 AM, Wednesday
Room C144, P32

Excitation energy dependence of the exciton inner ring

Y. Kuznetsova, 12:39 AM, Friday,
Room D163, Z22

Spin Texture in a Cold Exciton Gas

A. High, 10:48 AM, Friday,
Room D171, Y15

Electrostatic Lattice for Indirect Excitons

Depth controlled in-situ by voltage

- High speed control

Structure determined by electrode pattern

- Arbitrary lattice structures
- Compatible with semiconductor processing technology

Exciton number controlled by laser power

- Selective loading to individual lattice sites

Other controlled parameters

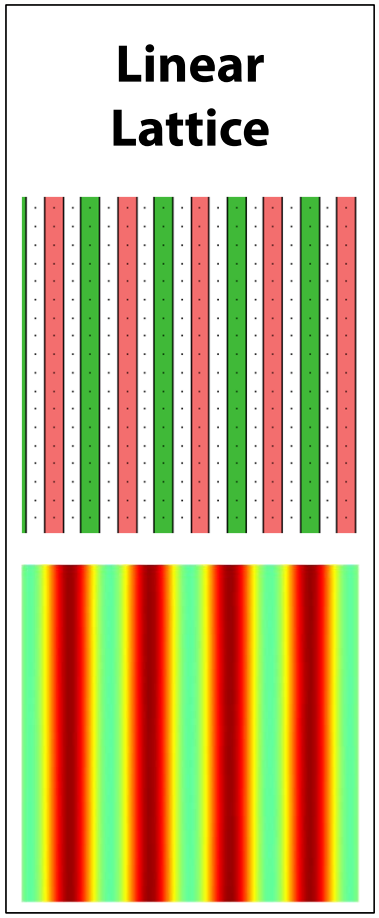
- Interaction strength
- Effective mass
- Exciton lifetime
- Exciton temperature

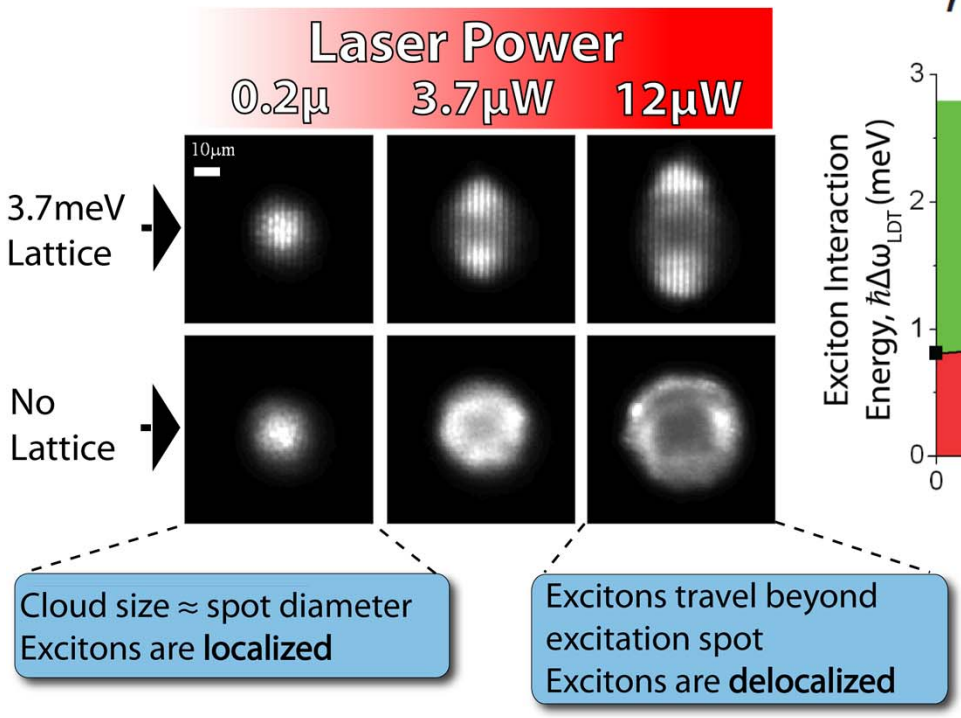
  Excitons can cool down below temperature of quantum degeneracy

Another system with many controllable parameters: cold atoms in optical lattices

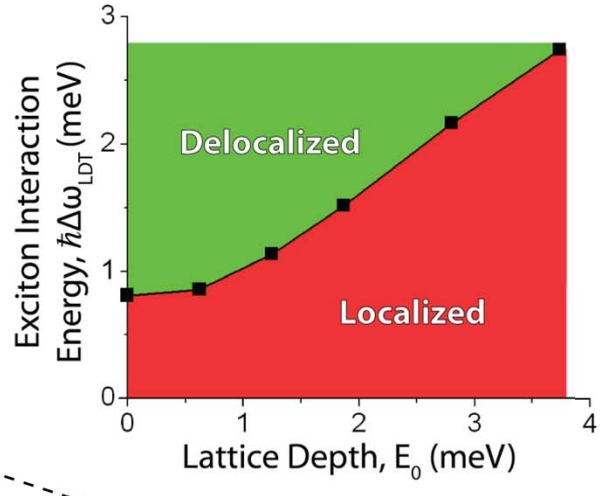
- Cold particles
- Tunable lattice depth
- Could emulate properties of condensed matter systems

Excitons in an Electrostatic Lattice





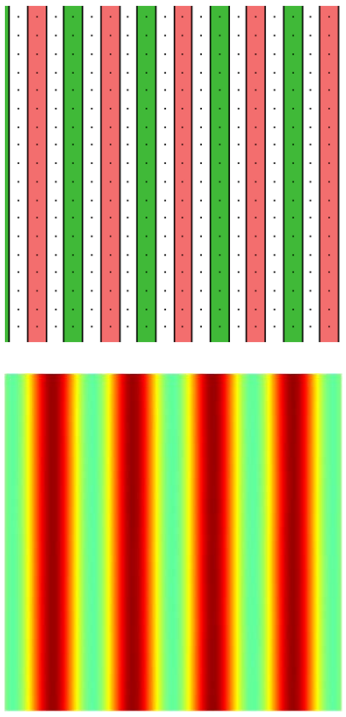
$$\hbar \Delta \omega_{\mathrm{LDT}} \approx E_0,$$



M. Remeika, J. C. Graves, A. T. Hammack, A. D. Meyertholen, M. M. Fogler, L. V. Butov, M. Hanson, A. C. Gossard *PRL*, 102,186803 (2009)

Two Dimensional Lattice Design

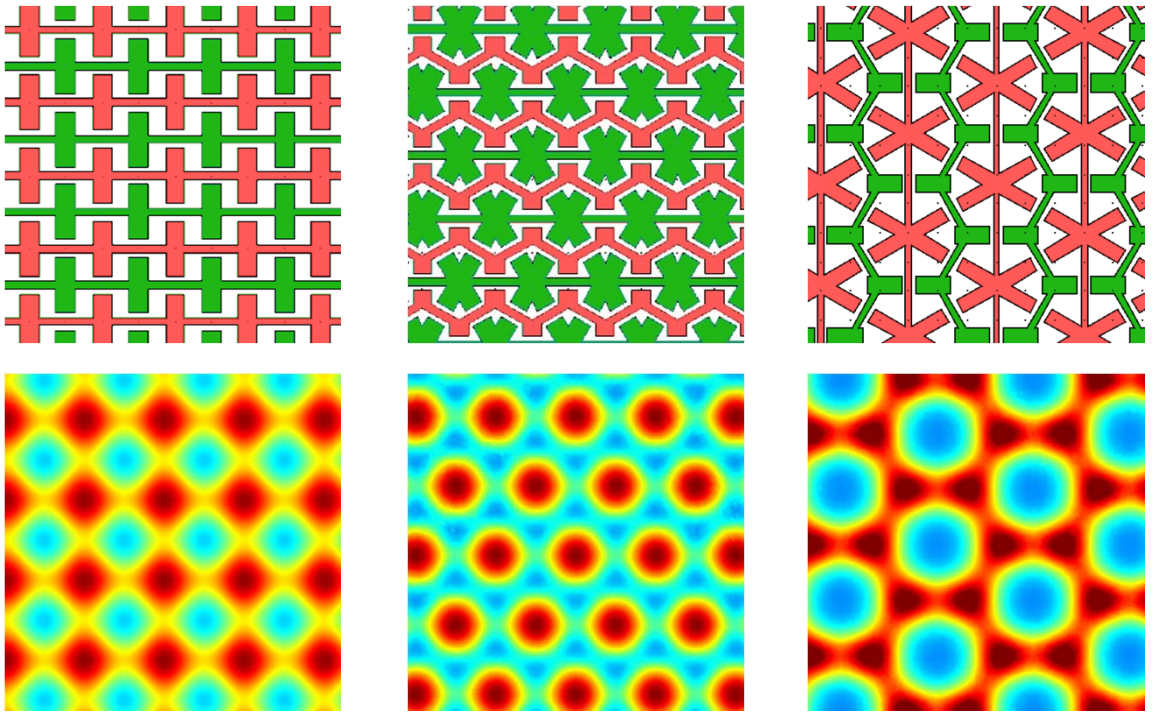
Linear Lattice



Two Dimensional Lattice

- Different lattice structures
- Onsite interaction (dipole blockade – Coulomb blockade)

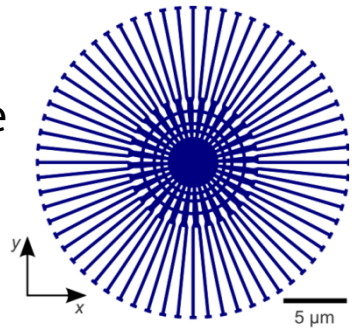
Square Triangular Honeycomb



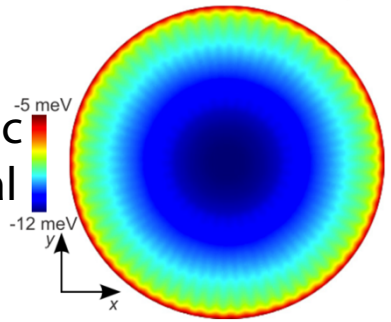
Two Dimensional Lattice Design

Method of Potential Control by Electrode Density

Snowflake trap



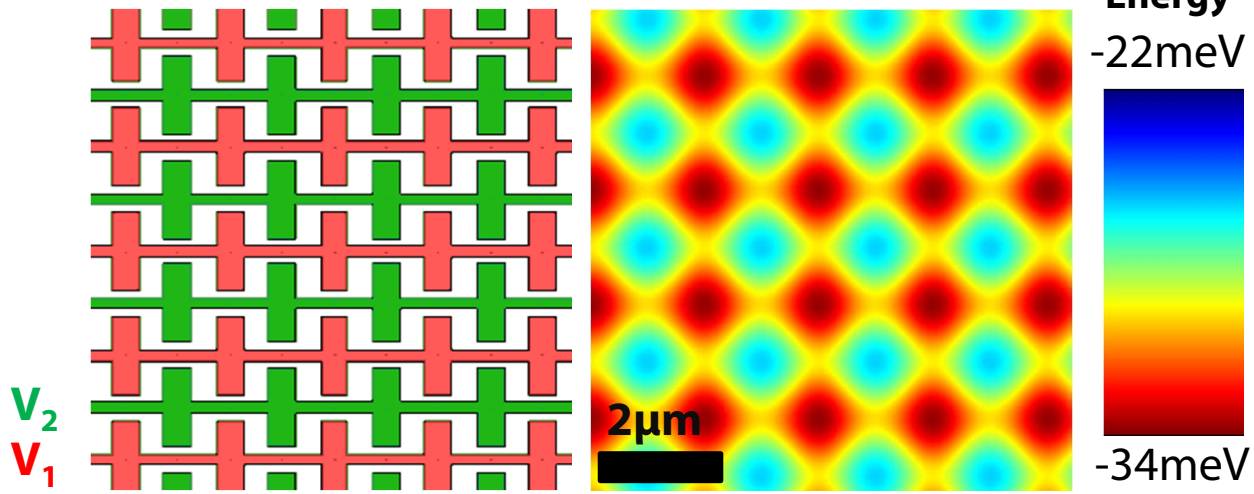
Parabolic Potential



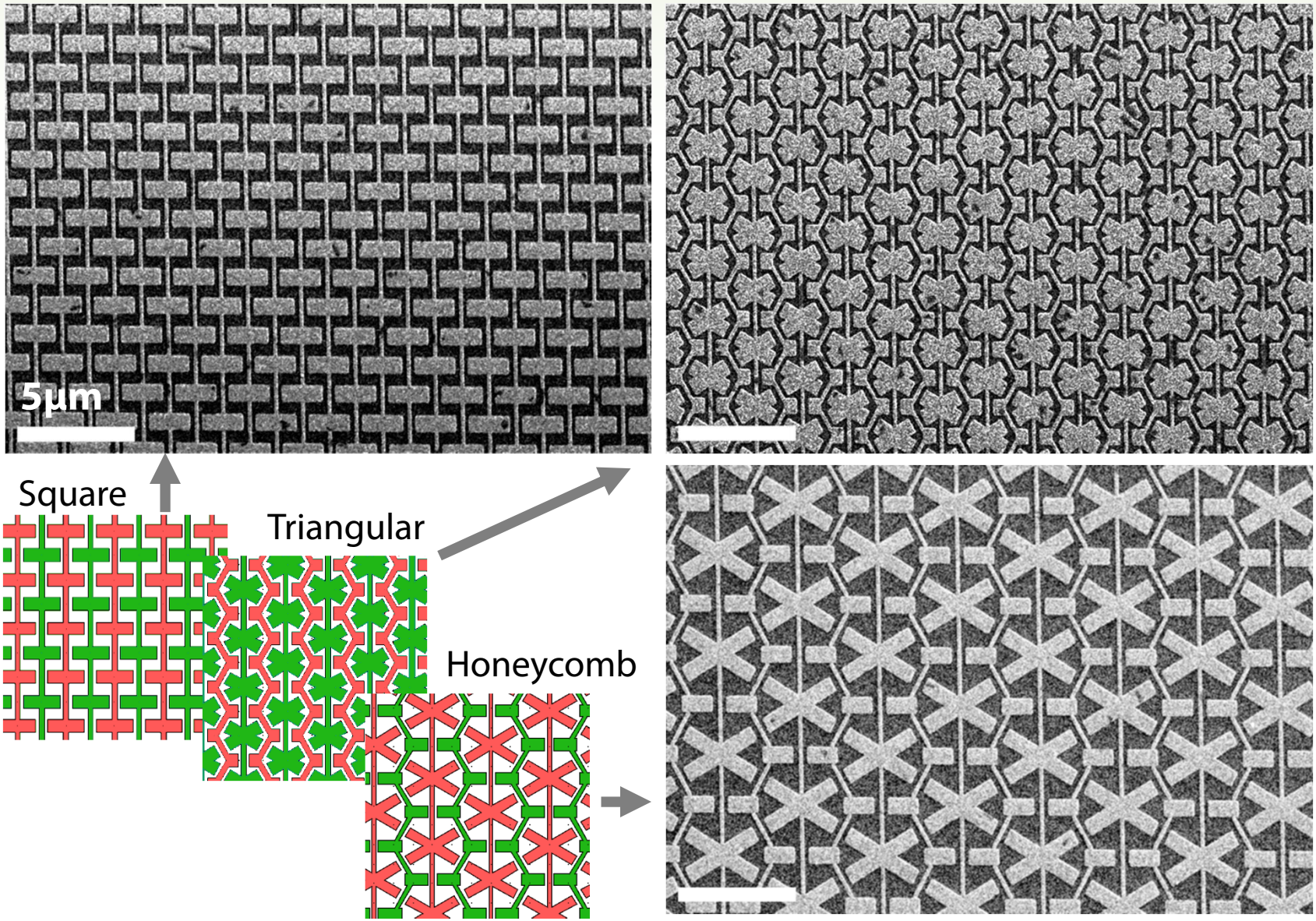
Y. Y. Kuznetsova, A. A. High, L. V. Butov *APL*, 97, 201106 (2010)

Applied to a Lattice Potential:

- Lattice structure determined by electrode design
- Independently controlled lattice depth and base energy
- Electrode pattern fabricated in a single lithography step

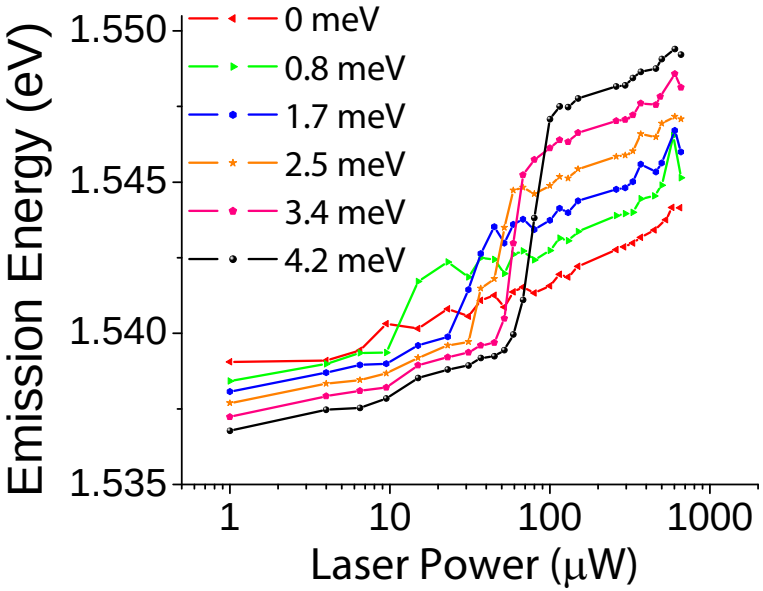


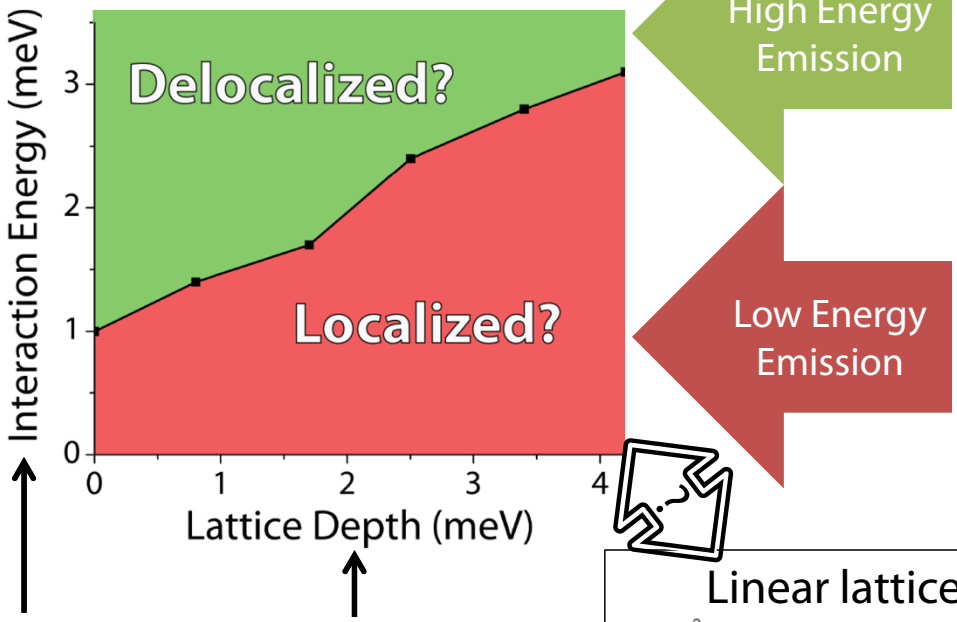
SEM Images



Preliminary Data on Excitons in a 2D Lattice

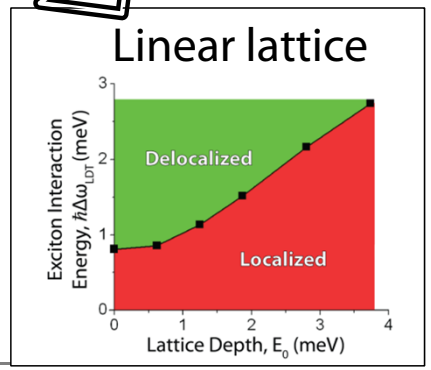
Work in progress





Measured by exciton energy shift

Controlled by voltage



Conclusions

- Developed a method to create 2D electrostatic lattices for excitons.
- Realized square, triangular, and honeycomb lattices.
- Analysis of exciton localization-delocalization transition as a function of exciton density and lattice amplitude is in progress.